IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of

Hiroshi FUKSHIMA et al.

Serial No. 10/575,489 Art Unit: 2879

Filed: April 12, 2006 Examiner: Minchul YNAG

For: A METHOD FOR PRODUCING A LIGHT-EMITTING DEVICE

DECLARATION UNDER 37. C.F.R. 1.132

Honorable Commissioner for Patents
U.S. Patent and Trademark Office
Customer Service Window, Mail Stop
Randolph Building
401 Dulany Street
Alexandra, VA22314

I, Hiroshi FUKSHIMA, declare that:

I obtained a Ph. D from the Kobe University graduate school of Science and Technology in 1990, and subsequently joined the Panasonic Electric Works Co., Ltd. in 1990. I have been mainly involved in the research and development in the field of the micro-fabrication process and optics for about 18 years. I have advanced knowledge and plenty of experience in the above field.

It was not easy to specify the lower limit value (5 MPa) and the upper limit value (150 MPa) for "a desirable pressure to be applied to a mold against the transfer layer of a silicon organic solvent formed on a semiconductor". It required experimentation over a long period of 200 hours. There was a series of difficulties leading up to the obtainment of the above limit values for applied pressure. The difficulties in obtaining these limit values, demonstrating more than routine experimentation, are set forth below:

Firstly, in order to experimentally confirm the relation between the pressure to be applied to the mold and the formation of the minute unevenness structure, it was necessary to form the transfer layer to a thickness in a range of 1.5 μm to 2.0 μm. Namely, the minute unevenness structure on the light-emitting device preferably had a pitch of 3 μm, and the unevenness structure formed on the mold needed to have a pitch of around 3 μm. In the case of fabricating a mold by wet etching taking advantage of crystal orientation of silicon (Si), the resulting mold would have a thickness of around 2.1 μm for the pitch of 3 μm. Therefore, the thickness of the transfer layer needed to be 1.5 μm or thicker.

However, at the time the invention was made, the transfer layer could be formed at most to the thickness of around 1.0 μm. Further, there was no known technology even for a resist manufacturer to form the transfer layer, by using the silicon organic solvent to any thickness greater than 1.0 μm. We therefore struggled to find a way to form the transfer layer by using the silicon organic solvent to the required thickness in the range of 1.5 μm to 2.0 μm. Then, the following process stages were required to form the transfer layer by using a silicon organic solvent to the required thickness.

Firstly, using the spin coating method, which was generally adopted at the time the invention was made, numerous attempts had been made varying the number of rotations to form the transfer layer to a required thickness. Despite these efforts, the transfer layer could not be formed to the required thickness as summarized in FIG. 1.

Next, the multi-layered coating was adopted to form the transfer layer by repetitively carrying out the process of applying a solvent to the light-emitting device, and then trying the solvent applied to the light-emitting device. When adopting PMMA(polymethyl-methacrylate) as the solvent, the transfer layer could be formed to the required thickness by the multi-layered coating as shown in FIG. 2. However, as shown in FIG. 3, when adopting the silicon organic solvent as the solvent, the transfer layer could not be formed to the required thickness even after carrying out many trials. We had invested a lot of time and effect to find a cause of failures. As a result, we determined, in the case of adopting the silicon organic solvent as the solvent, a subsequently applied solvent layer would melt an earlier applied solvent layer, thus causing a majority of the failures. We tried various processes to find a solution to the foregoing problem and finally found that the transfer layer could be formed by using the

silicon organic solvent to a required thickness by the best process we developed while potting a large amount of silicon organic solvent onto the light-emitting device.

As described above, the lower limit value (5 MPa) could not have been specified if we did not determine the process of forming the transfer layer by using the silicon organic solvent to the required thickness for confirming the effect of the pressure applied to the mold.

It was not easy to specify the upper limit value (150 MPa) either. It was known at the time the invention was made that the pressure to be applied to the mold could be appropriately evaluated based on the luminous intensity. However, it was unknown as to by what process, the relation between the pressure applied to the mold and the luminous intensity could be confirmed. As a result of carrying out various research, we found it appropriate to carry out the experiments by the time-resolved photoluminescence method. However, there were not many facilities, at the time the invention was made, which had the equipment for such experiments by the time-resolved photoluminescence method.

Additionally, there was no precedent establishing a method for which the experiments should be conducted in order to find out the effects of the pressure applied to the mold on the light-emitting device. We could not do anything other than work out the experiment method ourselves.

We made many trials ultimately leading to the best experiment method. The upper limit value was finally obtained by adopting the best experiment method we developed. As described above, to specify the limit values recited in claims, more than just routine experimentation, requiring exertion of our originality and ingenuity was needed.

I hereby declare all statements made herein of may own knowledge are true and that all statements made herein on information and belief are believed to be true; and, further that these statements were made with the knowledge that willful false statements and the lie so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application or any patent issuing thereon.

FIG. 1

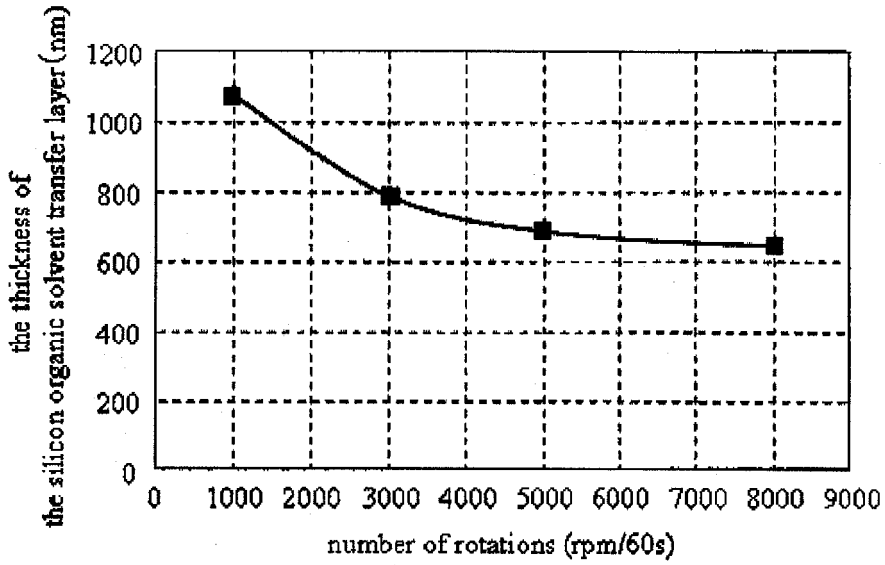

the thickness of the silicon organic solvent transfer layer (nm)
1200
1000
800
600
400
200
0
0 1000 2000 3000 4000 5000 6000 7000 8000 9000
number of rotations (rpm/60s)

FIG. 2

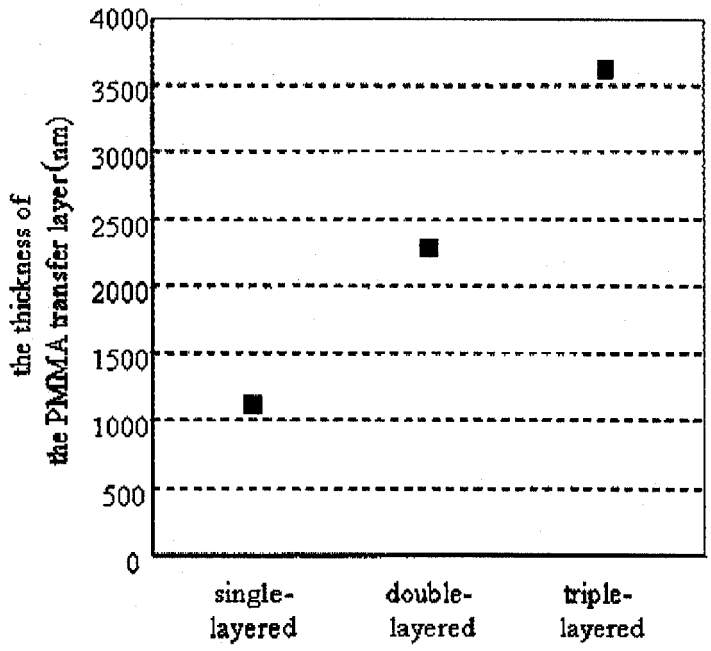
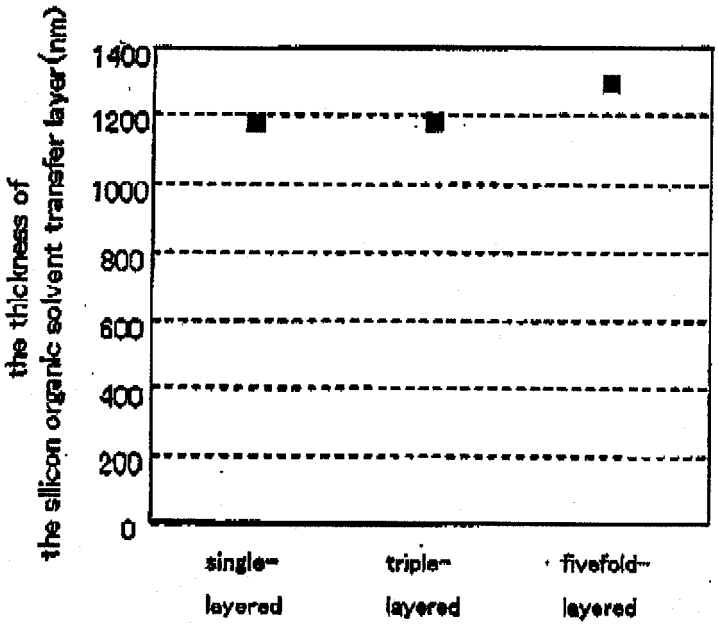

the thickness of the PMMA transfer layer (nm)
4000
3500
3000
2500
2000
1500
1000
500
0
single-layered
double-layered
triple-layered

FIG. 3



Hiroshi Fukushima

Hiroshi FUKSHIMA

Date Mar. 09/2009